SOME PROBLEMS IN CECIDOLOGY

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It is very doubtful if any phase of biology has been neglected more than that very conspicuous and extremely puzzling branch known as cecidology. This subject in its broadest sense includes all forms of abnormal plant growth regardless of cause. It must include, therefore, not only the hypertrophies, but also the witches brooms. It must include the abnormal growths caused by flowering plants, fungi, bacteria, insects, nematodes, and chemical and mechanical injuries. It must also include that great number of abnormal growths from unexplained causes which are included under the general term of teratology. Unfortunately, many of the botanists have interpreted the subject to include only those cecidia which are the result of insect injuries, and have attempted to relegate the entire subject to the entomologists, although they have not hesitated to study the cecidia caused by nematodes and bacteria, which might just as reasonably be forced upon the zoologist and bacteriologist.

The fact that the mycologists have usually been interested in the fungi and not in the host plant, explains why so much interesting material has been thrown aside with the single comment, "bugs." But with the development of plant pathology, a branch of botany which is necessarily interested in the pathological condition of the host, there is no longer any excuse for not giving a reasonable consideration to all phases of cecidology.

It is the purpose of this paper to call attention to some of the problems involved in cecidology, and to their bearing on other phases of biology, more especially botany. Cecidology is as old as the science of biology, and cecidia are referred to in some of the earliest biological literature. That cecidia were the subject of speculation, if not of study, is evidenced in the writings of REDI,[1] who, like other vitalists of his period, believed plants were endowed with souls and that the soul of the plant controlled the formation

[1] REDI was born in 1626.

of both the egg (i.e., the gall) and the insect which emerged from it, and determined their specific characters. As in all other biological subjects, the first real scientific work was taxonomic in character, and in 1686 MALPIGHI, who was a physician to Innocent XII and professor of medicine in Bologna and later in Messina, published his *De Gallis*, in which he gave quite accurate descriptions of the known galls of Italy and Sicily. Following this work, which may be looked upon as the starting point for cecidology, LINNAEUS and many other later writers gave more or less attention to this subject, which has attracted so much attention in Europe during recent years. In America, the pioneers in this subject were Baron C. R. OSTEN-SACKEN, BASSETT, WALSH, RILEY, FITCH, SHIMER, and HARRIS, all of whom were entomologists.

Although the entomologists have done more work in cecidology in both Europe and America than the botanists, their work has been no broader. The entomologists have studied the insects and described the cecidia which were attributed to them, and in the case of the injurious species have devised means for their control. The botanists have done the same work for fungi which cause cecidia, and have also invaded the fields of the bacteriologist and zoologist and studied not only the cecidia produced by bacteria and nematodes, but have even studied the organisms.

Taxonomy seems to be the forerunner of all lines of biological work, and this has been true of cecidology, but we have now reached a point from which we can extend our studies into other phases of the subject. We can now study the subject with reference to other phases of biology, in fact other phases of biology are encroaching upon the subject of cecidology. With this new development, the entomologist, the mycologist, and others will continue to find ample fields for the study of taxonomy. The entomologist will also have those almost untouched fields of life history and of alternation of generations which came so near to demonstration by our fellow-countrymen, H. F. BASSETT, and which was afterward demonstrated by HERMAN ADLER.

The various groups of botanists will find especially rich and almost untouched fields in many directions. The anatomical and histological characters and the development of cecidia have

been the subject of extensive studies in Europe, but have received very little attention in America. These studies when properly carried out and correlated with the work of the taxonomists will in turn open broad and unexplained fields in evolution. The pathology of the plants which are suffering from the attacks of these many cecidia-producing organisms cannot be overlooked by the plant pathologists, who have no more right to refer insect cecidia to the entomologist than the surgeon has to send the patient suffering from a gun-shot wound to the gunsmith. Both the economic entomologist and the plant pathologist will find enough problems to keep them busy for many years to come. It is doubtful if the entomologist has said the last word on the *Phylloxera vastatrix*, *Schizoneura lanigera*, *Eriophyes pyri*, and many other cecidia-producing insects which attack economic plants; and it is undoubtedly true that the plant pathologist has scarcely touched many of the economic problems involving cecidia-producing fungi and bacteria. The cytologist will also find a field for his labor.

However, the most difficult and probably the most fruitful field is open to the plant physiologist; the character of the stimuli which excite malformation is a question well worth the attention of any group of scientists, and one which if answered may be very far reaching in its influence. The botanists have doped the plant with many chemicals, with some of which it may never come in contact in a state of nature; they have subjected it to the various kinds and degrees of gases, light, moisture, and temperature; treated it with electricity; prodded it with everything imaginable from a most delicate needle to a crowbar; and otherwise subjected it to various normal and abnormal conditions, but have made little or no effort to determine the character of the stimuli which cause the formation of cecidia. DARWIN and all his predecessors believed that the cecidia are directly or indirectly the result of a chemical secreted by the mother insect at time of oviposition; MALPIGHI believed that the chemical causes a fermentation of the juices; REAUMUR[2] held the same view, but also believed that the thermal effect of the egg and the character of the wound, which varies with the different species of the insect, are important factors. Sir

[2] Mémoires pour séries à l'histoire des insectes. Mémoire XII. Vol. III. 1738.

JAMES PAGET, as late as 1880, said that "the most reasonable, if not the only reasonable theory, is that each insect infects or inoculates the leaf or other structure of the chosen plant with a poison peculiar to itself." Unfortunately, this view is still held by most of our biologists, although the researches of the past thirty years have demonstrated that it is almost without foundation.

In 1881 Dr. HERMAN ADLER[3] published the results of his long and careful studies, in which he gave the first real scientific evidence concerning the nature of the stimuli and character of gall formation. According to his results, the fluid secreted by the oak-gall fly is not irritating, and is not a factor in gall formation, but may serve as an antiseptic dressing for the wound in the plant. This view is strengthened by BEYERINCK,[4] who demonstrated that the fluid is without taste or smell and not irritating when injected under the skin. ADLER advanced the idea, which has been affirmed by other workers, that in the oak-gall flies, whatever irritating chemical exists comes from the larva and not from the parent insect. ADLER also reports his observation on *Nematus Vallismierii*, one of the saw flies, which attacks the *Salix amygdalina*. In this case the female pours out an abundant glandular secretion at time of oviposition, and the gall is well formed before the larva emerges from the egg.

It is also well known that mechanical stimuli will frequently cause abnormal growths. However, accurate data upon the results of various stimuli is not to be found in our literature.

ADLER says that the cecidia always originate from the formative cells of the plant, and that if the stimulation is applied to any other than the formative cells, cecidia are not produced. This statement opens up an enormous line of work. While some scale insects cause hypertrophies, others do not. Who has traced the ramifications of the mouth parts of these insects through the tissues of the host? Why do some Uredineae cause cecidia while other closely related species do not? Who has traced the mycelia of these related species

[3] Ueber den Generationswechsel der Eichengallen. Zeitschr. Wiss. Zool. **35**: 151–246. 1881. Translated in 1894 by CHARLES R. STRATON.

[4] Beobachtungen über die ersten Entwicklungsphasen einiger Cynipidengallen. Naturk. Verli. der Kon. Akad. Deel **22**: 179. 1882.

in their ramifications through the tissues of the host plants? Who has solved the chemical and enzyme relationships which may exist between these fungi and their hosts? If the insect cecidia are the result of chemical stimuli, how about the myco-cecidia? If the insect cecidia are due to mechanical irritation, how about the myco-cecidia? If the insect cecidia are the result of irritation applied to the formative cells, is the same thing true for the myco-cecidia? By what school of biologists should these problems be worked? Will not the solution of one set help in the solution of others?

The writer is not presenting these questions for the purpose of controversy, but merely to call attention of students to this enormous field of plant pathology and plant physiology. Give us more data concerning the relationship between parasite and host plant, regardless of the character of the parasitic organism. Let us tear away the artificial barriers and give the broadest study to these problems.

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